Response to Community Comments #1 by: Ulrik Kautsky

- The paper presents an interesting model study concerning potential effects of the hyporheic zone on groundwater flow patterns using a selection of the hydrological data available for Krycklan. In its present state the study is theoretical. The study would be strengthened if it included an analysis describing the extent to which the regional model was able to capture the hydrology at Krycklan. This would help to address questions about the validity of the regional hydrological model and may help frame results from the hyporheic, local-scale simulations as applicable to a real-world scenario.

  The paper would be further strengthened if it discussed the robustness of the results as affected by the parameterizations and structural assumptions made in the numerical and conceptual models. For example, the potential effects of landscape topography, time variation of streambed topography, rock fractures, soil stratification, spatial heterogeneity of streambed sediments, parameterization of the infiltration rate at the surface, and model boundary conditions are not discussed. Without such a discussion it cannot be deduced the extent to which variabilities in these, and other, variables will affect the hyporheic phenomena postulated in the modelling exercise; it is therefore not possible to assess the extent to which the results and/or methodologies presented in the study are relevant to other sites.

Thanks for the comments. This study was conducted in a specific watershed as a site-specific limitation, in terms of landscape topography, the geological heterogeneity of soil strata, and the available infiltration. Even though a sensitivity analysis using more parameters than were used in the presented Monte Carlo analysis could have been useful, the purpose was not to derive general conclusions that can be unconditionally used in other areas. In addition, the present study recognized uncertainties in the ways in which hydrostatic and dynamic head boundary conditions were represented in the model. The influences on the modeled results are analyzed using Monte Carlo simulations, which cover the uncertainties of the spatial and temporal variations in streambed properties with 1200 realizations. The uncertainty in this study is addressed in section 2.5 (lines 217-222). The Krycklan catchment can be divided into a number of sub-catchments. In this study, the modeled water travel times for the intermediate groundwater flowing from recharge areas to discharge points throughout the whole catchment are presented in Fig. 7. The median value is approximately 2.5 years, which is in the same order of magnitude as the results (1.2–7.7 years) obtained by a recently published study performed at the same catchment area (Jutebring Sterte et al., 2021). Jutebring Sterte et al. (2021) used a combination of observations of $\delta^{18}O$ and base cation concentrations in different streams, then conducted particle tracing (flow modeling using MIKE SHE II) to provide a consistent picture of the hydrological functioning of the Krycklan catchment. The following text will be added to the revised version (in section 4.1):

> *In this study, the modeled water travel times for the intermediate groundwater flowing from recharge areas to discharge points throughout the whole catchment are presented in Fig. 7. The median value is approximately 2.5 years, which is in the same order of magnitude as the results (1.2 – 7.7 years) obtained by a recently published study performed in the same catchment area (Jutebring Sterte et al., 2021).*

In addition, previous studies have shown the deterministic effects of topographical variation compared to heterogeneity in the fracture network within the bedrock domain on deep groundwater travel times in different subsurface strata, as well as their discharge zones at the topographical surface (Selroos et al., 2002; Marklund et al., 2008; Welch et al., 2012). Therefore, the uncertainty involved in the fracture network has a negligible effect on the results of this study. The following text will be added to the revised paper in order to address this comment:

> *Previous studies indicated that the deep groundwater discharge location at the topographical surface is primarily controlled by topographical variation, and the distribution of the fracture network may slightly change the discharge location (Selroos et al., 2002; Marklund et al., 2008; Welch et al., 2012). In this study, the bedrock domain was assumed to be an equivalent continuum subsurface stratum, where an average hydraulic conductivity with an exponential depth-decaying function (Figure 1) was considered to represent both the intact bedrock and fractures.*

References

Jutebring Sterte, E., Lidman, F., Lindborg, E., Sjöberg, Y., and Laudon, H.: How catchment characteristics influence hydrological pathways and travel times in a boreal landscape, Hydrology and Earth System Sciences, 25, 2133-2158, 2021.

Marklund, L., Wörman, A., Geier, J., Simic, E., and Dverstorp, B.: Impact of landscape topography and Quaternary overburden on the performance of a geological repository of nuclear waste, Nuclear technology, 163, 165-179, 2008.

Selroos, J.-O., Walker, D. D., Ström, A., Gylling, B., and Follin, S.: Comparison of alternative modelling approaches for groundwater flow in fractured rock, Journal of Hydrology, 257, 174-188, 2002.

Welch, L. A., Allen, D. M., and Van Meerveld, H.: Topographic controls on deep groundwater contributions to mountain headwater streams and sensitivity to available recharge, Canadian Water Resources Journal/Revue canadienne des ressources hydriques, 37, 349-371, 2012.